

# SASSI (A System for Analysis of Soil- Structure Interaction) Subtraction Method Considerations

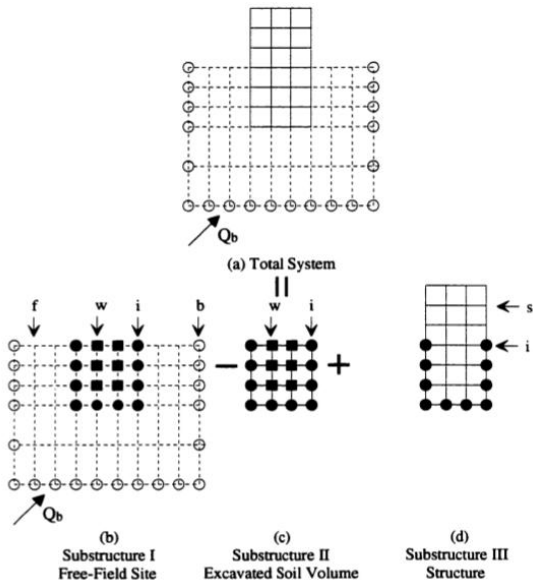


# History

- SASSI, for finite element analysis of soil-structure interaction (SSI), released by UC Berkeley in 1981. Originally executed with flexible volume, or Direct Method (DM).
- The Subtraction Method (SM) for executing SASSI was published in 1998; provided significant computational efficiency.
- Modern computational capacity has allowed for SSI analysis of larger embedded structures using the SASSI analysis methodology.
- Current guidance now requires higher cutoff frequencies of analysis (50 Hz).
- The current computational capacity, along with the higher frequencies of analysis have identified failures in the SM to produce accurate results beyond an identifiable frequency cutoff.

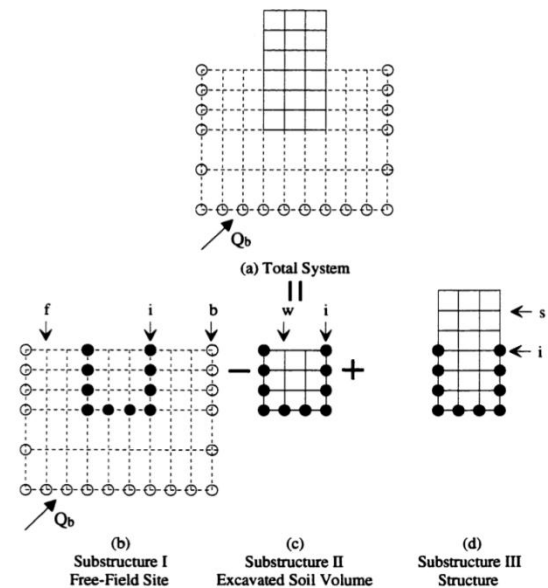
# Comparison

## Direct Method



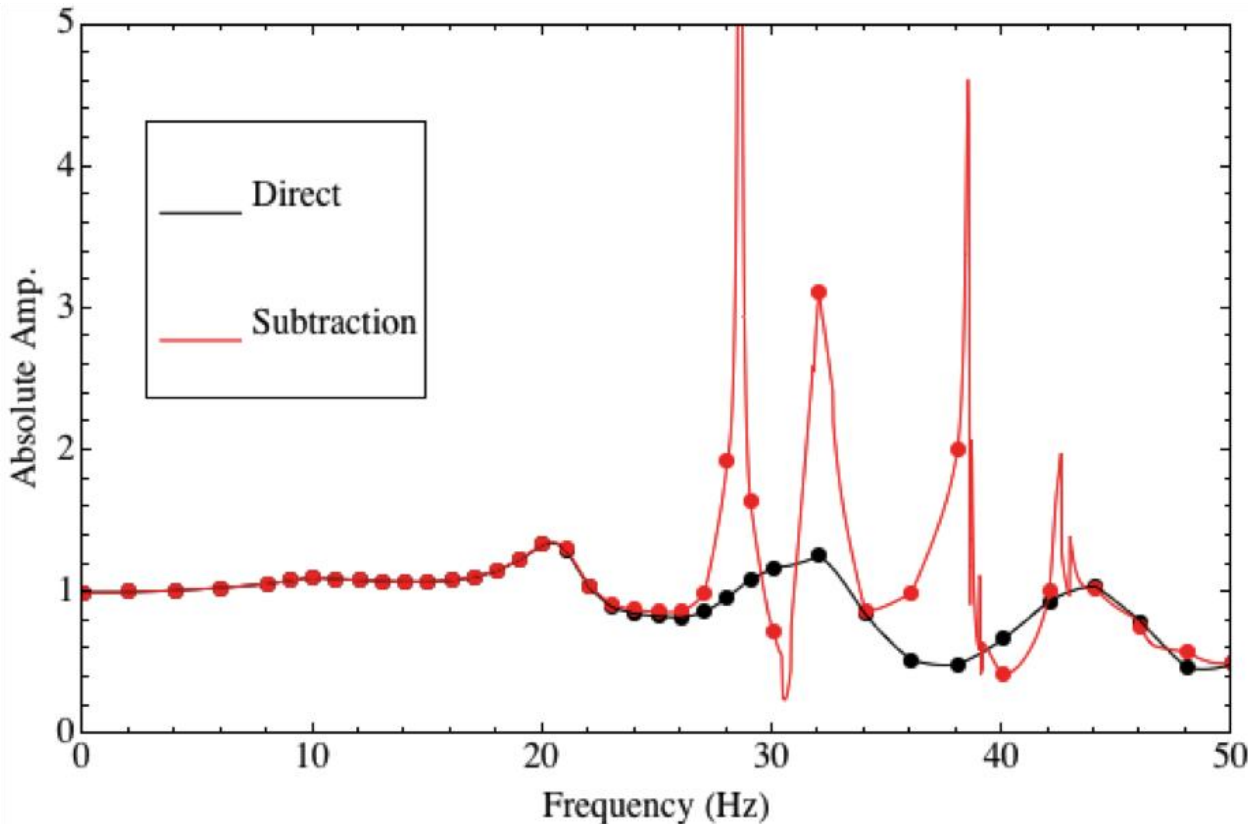
Every finite element node on periphery and within an excavated soil volume is defined as an interaction node.

## Subtraction Method



Gains efficiency by treating only peripheral nodes as interaction nodes. Assumes all interaction between the structure and site occurs only at the boundary of the excavation.

# Example of the Subtraction Method Error



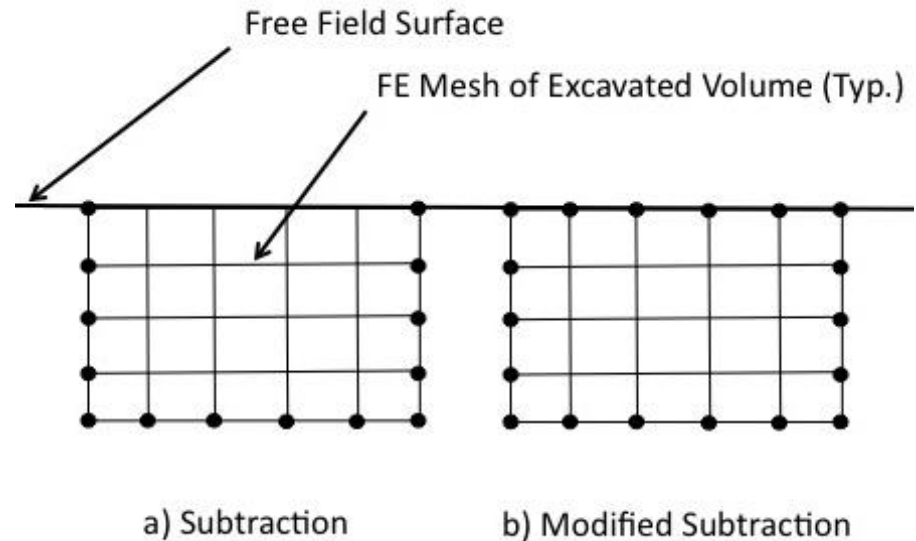
- The figure to the left shows a sample of the SM error in a UPF project study.
- The figure shows absolute amplification vs. frequency for a single SSI analysis.
- The SM error initiates near 27 Hz in this problem where the SM deviates from the DM.

# Cause of the SM Error

- As the size of the embedded problem grows and the frequency of analysis increases, the excavated volume can vibrate on its own causing spurious results.
- This error occurs roughly at the frequency computed by  $V_s/4H$ , where  $V_s$  is shear wave velocity of the excavated volume, and  $H$  is the height.
- Several forms of the Modified Subtraction Method (MSM) have been used in DOE projects to avoid this error in the frequency range of interest.
- The MSM is not a panacea. It adds interaction nodes to the excavated volume which results in shifting the error to higher frequencies. These frequencies may be beyond the cutoff frequency of interest to the structure and components being analyzed.

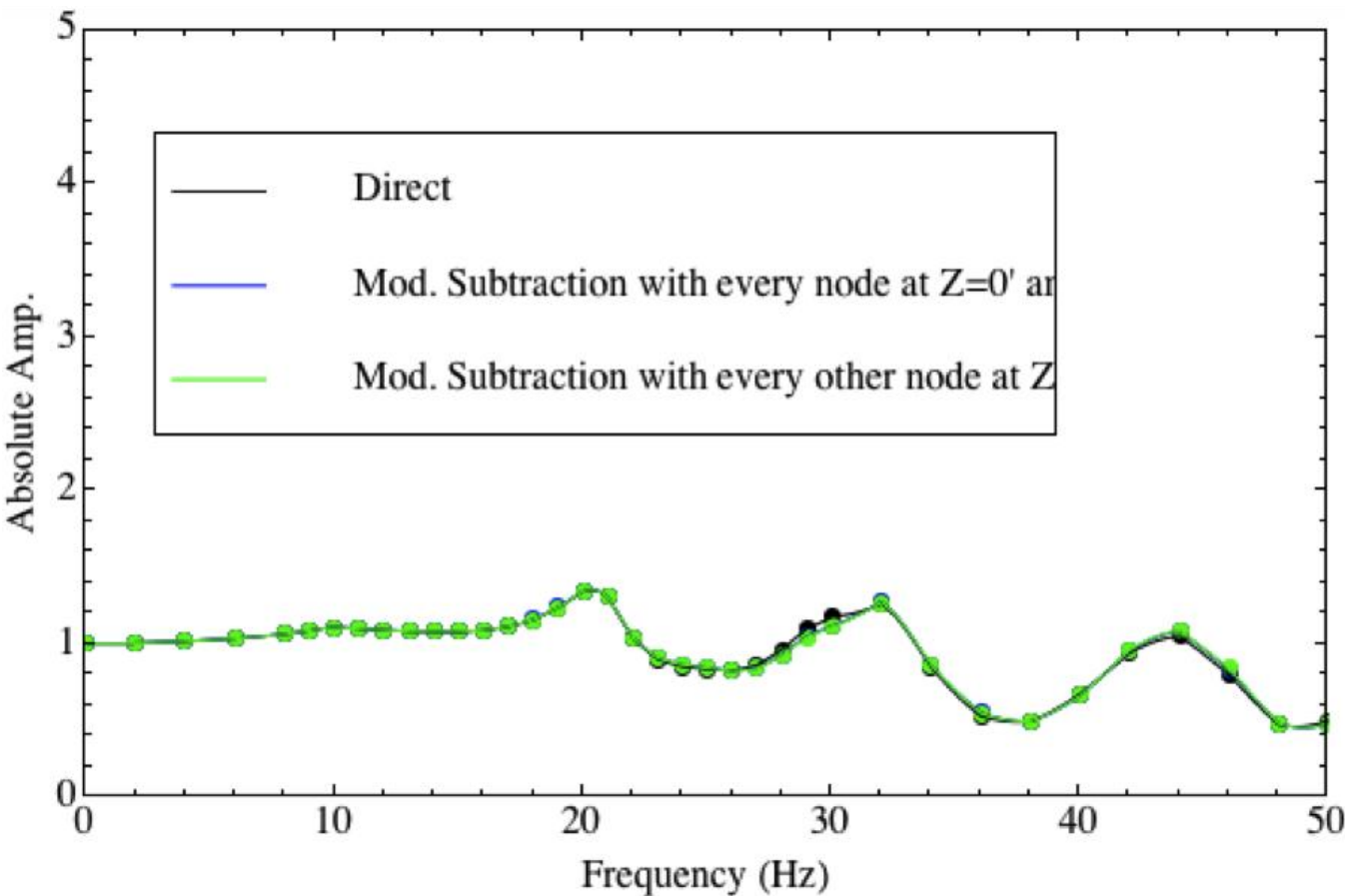
# Modified Subtraction Method (MSM)

- The MSM adds interaction nodes at the top surface of the excavated volume.
- This roughly doubles the allowable cutoff frequency.
- The error still can occur, but typically at a frequency beyond the range of interest for SSC's.
- The MSM or a variation thereof is being implemented on several DOE projects.



● Interaction Nodes

# Example of the MSM vs. DM



- The figure to the left shows SSI response using the MSM and DM for the same problem shown earlier.
- In this case, the MSM performs well relative to the DM.



# Recent Chronology

- July 2010: LA-UR-10-05302 identified incorrect results from some subtraction method analyses.
- August 2010: DOE-CNS commissioned a team to examine the problem and make recommendations to DOE.
- April 2011: DNFSB letter to DOE asking for a report and briefing on how DOE will address SASSI technical and software QA issues.





# Current Status

- DOE SASSI team has completed their report; DOE in process of transmitting to affected sites.
- Report provides guidance for reviewing past analyses and performing future analyses.
- DOE finalizing response to DNFSB letter, committing to produce additional guidance and V&V problems.